Managing Our Snow

FOR A BETTER WATER SUPPLY

CALIFORNIA COOPERATIVE SNOW MANAGEMENT RESEARCH

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
PACIFIC SOUTHWEST FOREST AND RANGE
EXPERIMENT STATION

in cooperation with

STATE OF CALIFORNIA
DEPARTMENT OF
WATER RESOURCES

Half of California's water comes from the State's high mountain snow zone . . .

Cover Photo: Headwaters of the American River looking south from the summit of Mt. Disney near Soda Springs, site of the Onion Creek Experimental Watersheds.

THE RESEARCH CHALLENGE

More Water from the Snow Zone

Research aimed at improving California's water supply through . . . .

MANAGEMENT OF LAND IN THE SNOW ZONE

. . . . was started in July of 1956 by the Pacific Southwest Forest and Range Experiment Station with the State of California's Department of Water Resources.

Other cooperators are lending a hand:

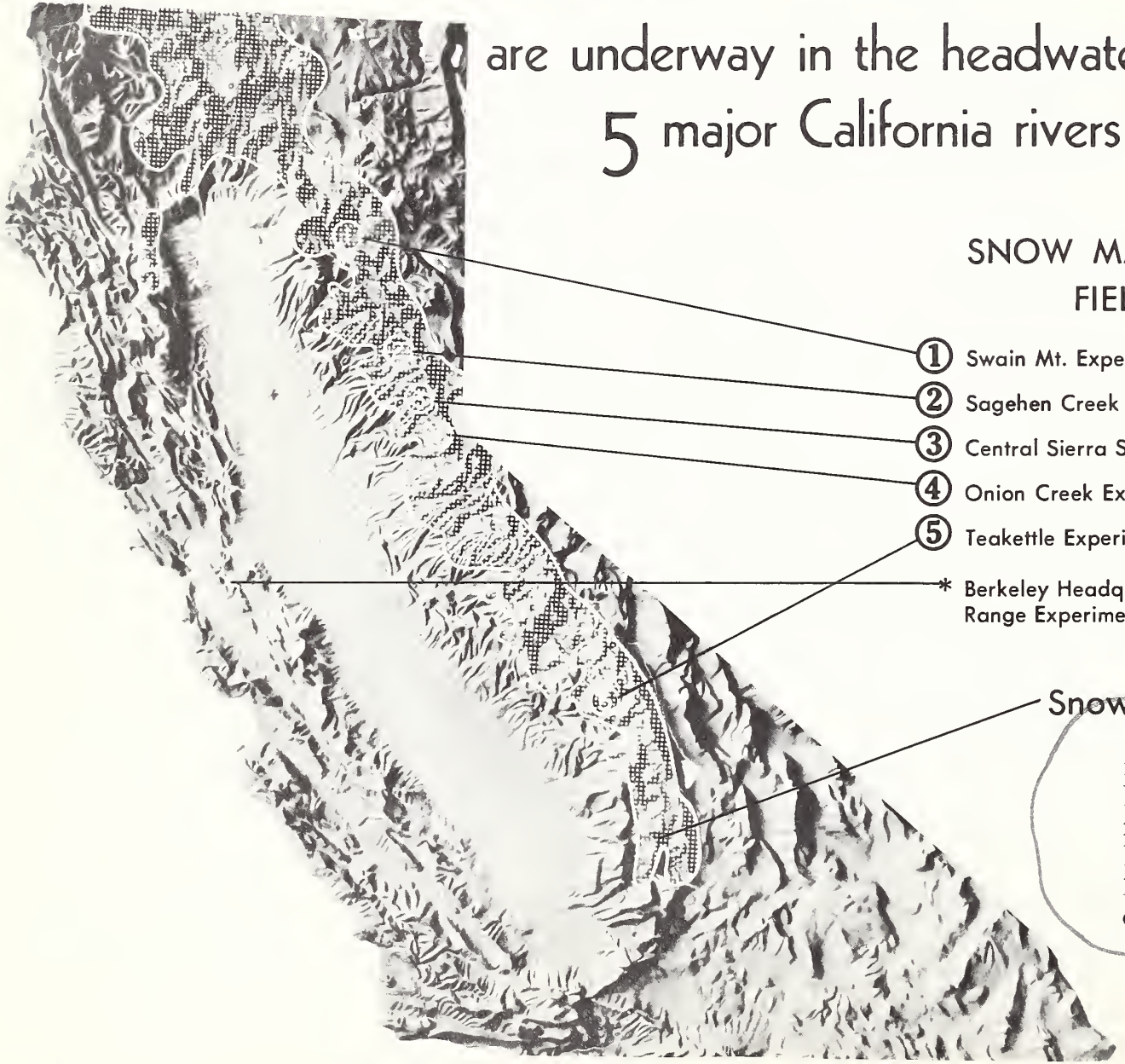
- The University of California
- The U.S. Weather Bureau
- The Pacific Gas and Electric Company

The Experiment Station, in turn, is furnishing information to these agencies and others concerned with flood forecasting, water supply, and water quality.

What management measures will improve the supply of water from snow zone forests . . . brushlands . . . and alpine areas?

18 Snow Management Studies

are underway in the headwaters of 5 major California rivers



SNOW MANAGEMENT RESEARCH FIELD LABORATORIES

1. Swain Mt. Experimental Forest (Feather River)
2. Sagehen Creek (Truckee River)
3. Central Sierra Snow Laboratory (Yuba River)
4. Onion Creek Experimental Forest (American River)
5. Teakettle Experimental Forest (Kings River)

* Berkeley Headquarters, Pacific Southwest Forest and Range Experiment Station

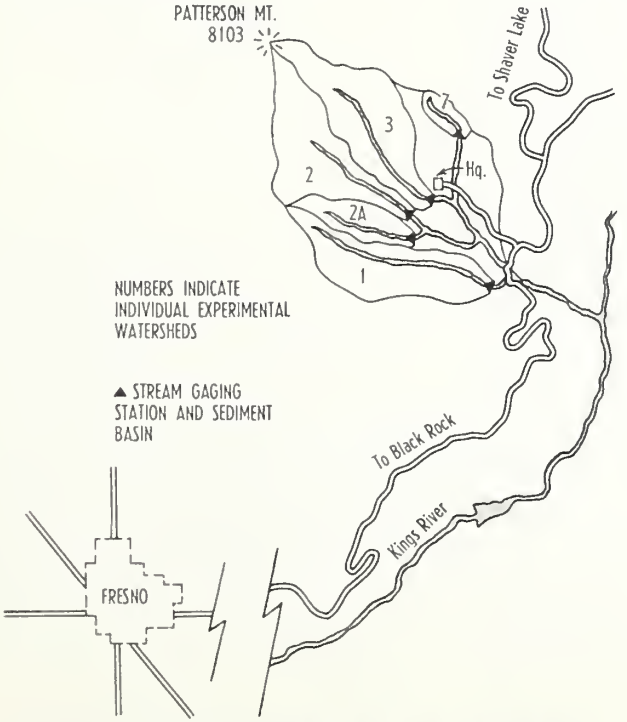
Snow Zone

. . . . lies above 5,000 feet in southern Sierra Nevada and above 3,500 feet in northern Sierra Nevada and Cascades . . . 12 million acres or 12% of State's total land area.

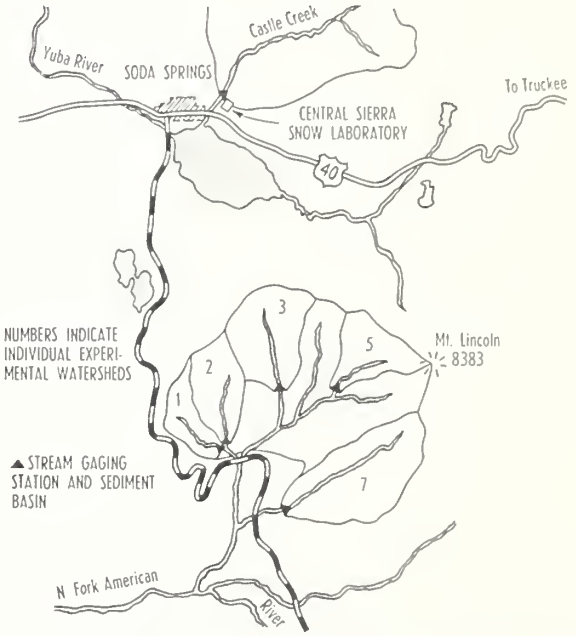
MAIN EXPERIMENTAL WATERSHED AREAS

Many answers to the relationship of snow zone conditions to water yield will be obtained on the Onion Creek and Teakettle Experimental Watersheds. Here we are conducting studies in 10 test watersheds which vary in size from 70 to 700 acres.

Stream gaging stations and debris-catchment basins have been built to measure stream flow and sedimentation. These provide vital data on the watersheds' characteristics under natural conditions.



TEAKETTLE EXPERIMENTAL WATERSHEDS



ONION CREEK EXPERIMENTAL WATERSHEDS

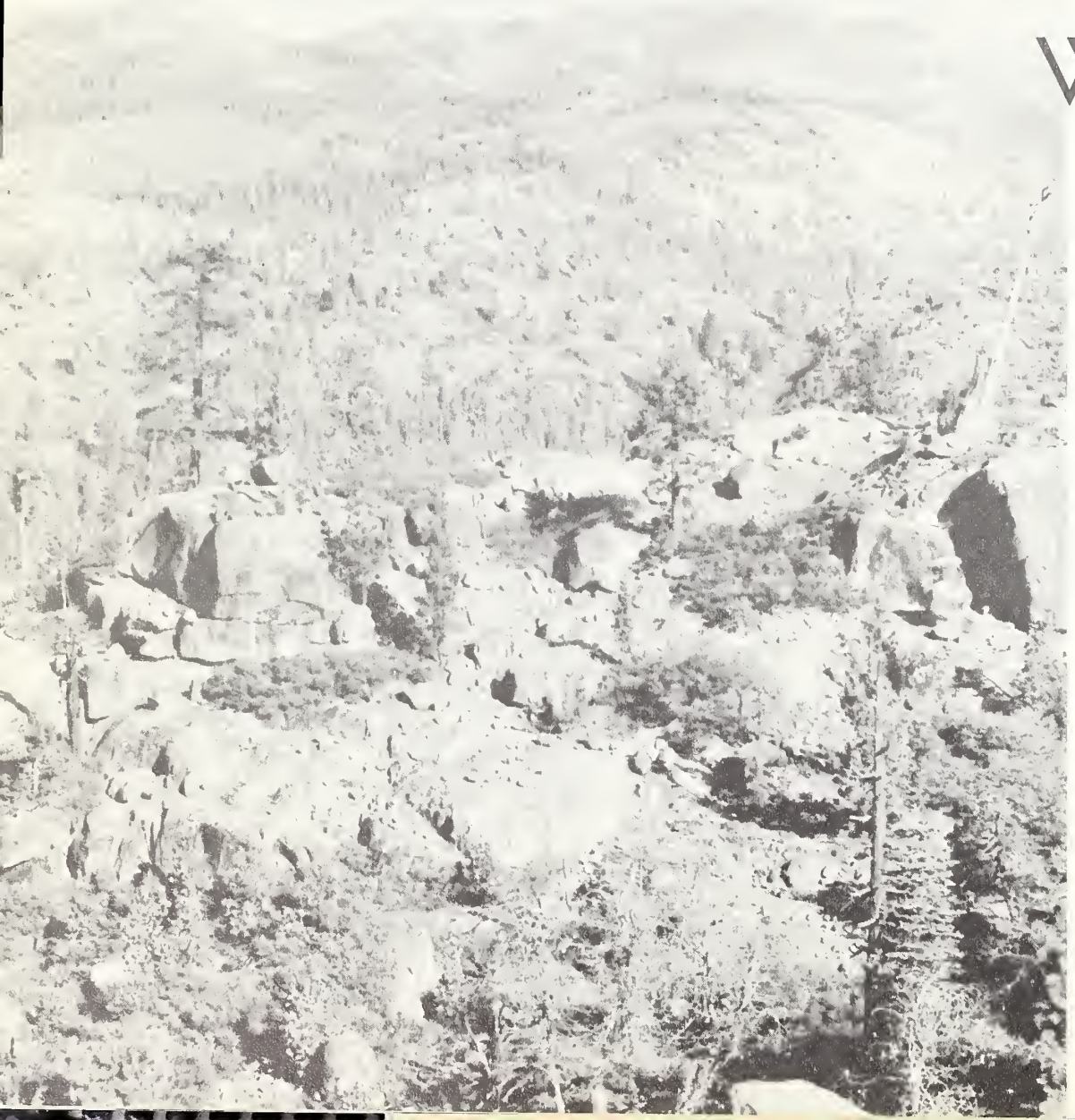
When sufficient data have been gathered, various watershed management test practices then will be applied to learn what happens under a variety of conditions.

These tests will be conducted for different objectives:

1. To get the maximum water yield.
2. To retard snow melt and delay water delivery.
3. To evaluate water production under multiple use—timber management, grazing, recreation, and wildlife.

THE SNOW ZONE

What Is It?



Aerial photographs and inventories of land conditions, water, and soil show us what the snow zone consists of:

- 27 percent of the snow zone is bare rock or bare ground
- 22 percent is tree crown covered
- 17 percent is brush covered
- 7 percent is grass-herb

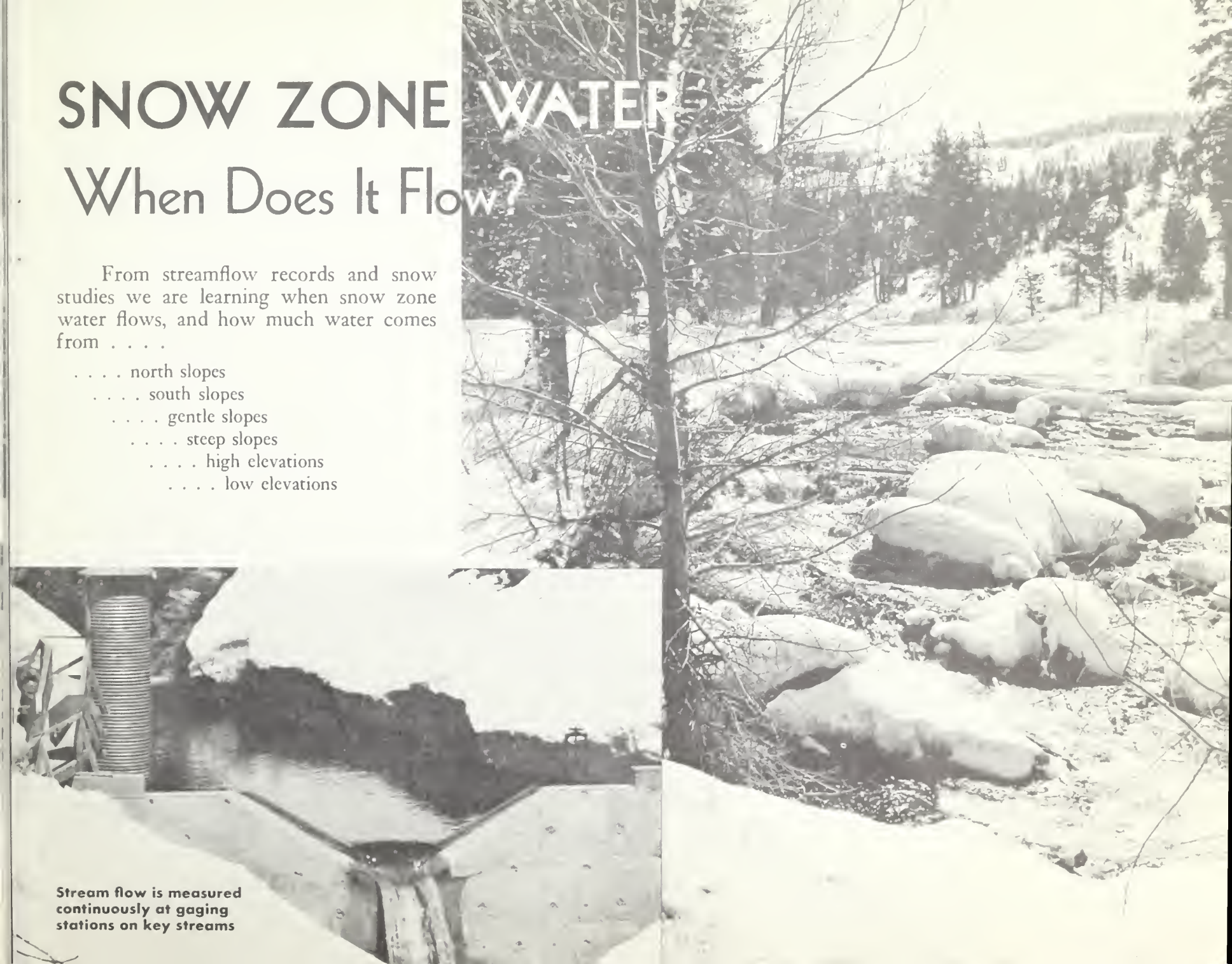
Each type of land condition requires separate investigation.

SNOW ZONE WATERS

When Does It Flow?

From streamflow records and snow studies we are learning when snow zone water flows, and how much water comes from . . . .

. . . . north slopes
. . . . south slopes
. . . . gentle slopes
. . . . steep slopes
. . . . high elevations
. . . . low elevations



Stream flow is measured continuously at gaging stations on key streams

WHICH SOILS HOLD THE MOST WATER?

Sampling and analysis will determine soil moisture storage capacities, their effect upon stream flow, and the soil's resistance to erosion.

WHICH ARE THE PROBLEM SOILS?

Sediment samples and reservoir surveys will help locate the principal sediment sources—the problem soils.

Snow Physics
Forest Meteorology
Stream Hydrology

. . . . these are the basic field studies concentrated at the Central Sierra Snow Lab. They are aimed at developing the best methods of increasing snow storage, delaying snow melt, and decreasing evaporation losses.

One of the First Questions:

FROM WHAT DIRECTION DOES THE SNOW COME?

Answer:

Snow lab measurements show that during snowstorms the wind blows from the south and southwest 83% of the time.

This may influence timber cutting patterns and other snow management practices.

HOW DOES SNOW ACCUMULATE

. . . IN FOREST STANDS?
. . . IN FOREST OPENINGS?
. . . IN BRUSH AREAS?

First Results Show:

- 14 inches more water was stored as snow in openings than in dense forest stands.
- Most unmelted snow late in the spring was found in forest openings about as wide as the surrounding tree heights.
- Selective cutting of forests increased water stored as snow by 2 to 9 inches depending upon the proportion of trees removed.

Photo by Sacramento Bee

HOW MUCH SNOW IS INTERCEPTED BY TREES?

How much snow is caught by the trees and evaporated back into the atmosphere?

During the Spring of 1958 about 8 percent of the snow landing in tree crowns never reached the ground, not even by melting.

Other studies in the snow zone have shown a 10 percent loss by interception of snow and a 13 percent loss by interception of rainfall.

HOW MUCH MOISTURE IS LOST FROM THE SNOWPACK?

Wind, sun, and dry air can remove snow from the pack. How do these losses differ under various forest conditions?

Snow evaporation is greatest from exposed ridges and large forest openings, less from small forest openings, and least where trees cover the ground. Near the Central Sierra Snow Laboratory, winter evaporation from snow under a forest stand was 0.9 inches, from a small forest opening it was 1.7 inches. Evaporation from a large meadow and an exposed ridge was one and one-half and three times that of the small forest opening.

Sometimes, when the air is moist, the cold snow condenses moisture from the warmer air, and gains from condensation exceed evaporation losses.

HOW MUCH WATER IS LOST FROM SOIL?

We have not yet found an accurate method for measuring winter soil moisture losses.

Summer losses can be measured. A radioactive soil-moisture probe gives quick, accurate answers.

The quantity of water stored in the soil is measured at the start of spring and again at the end of summer. The difference, added to rainfall that occurs during the summer, is the total summer water loss.

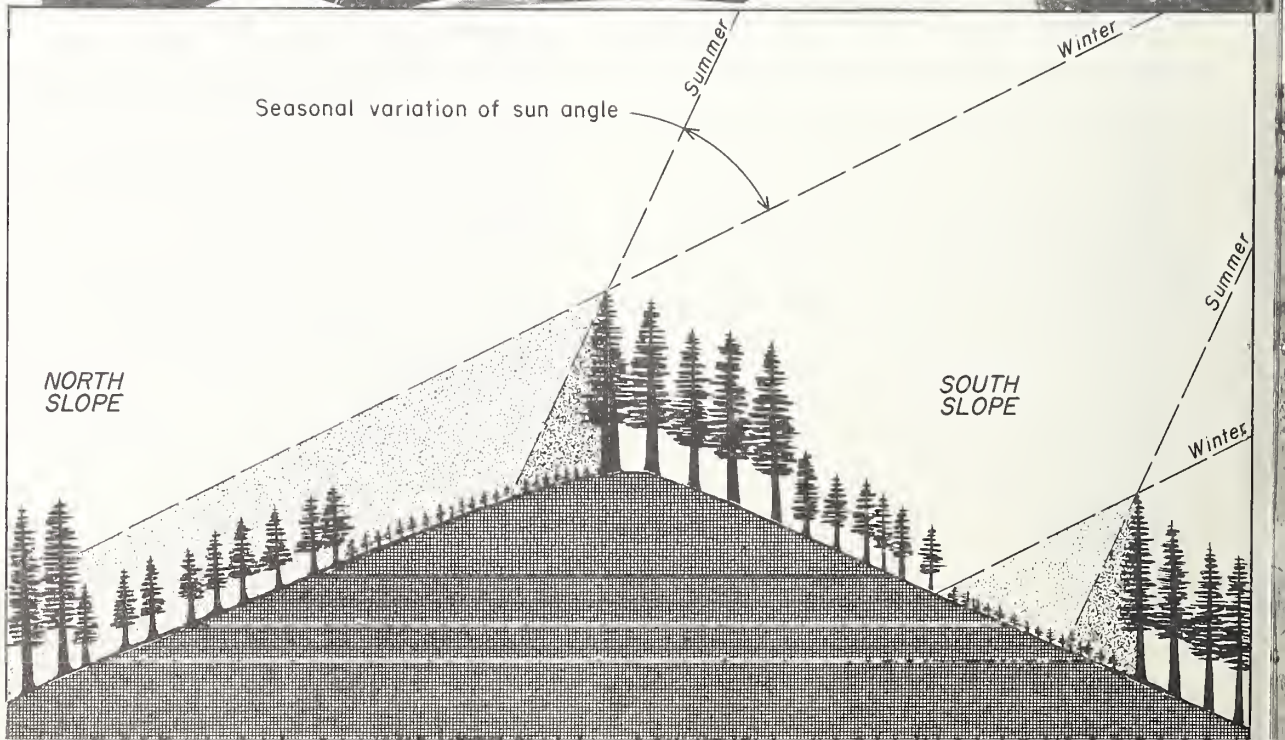
In the summer of 1958, studies near the Central Sierra Snow Laboratory showed that old growth red fir timber areas lost 7.7 inches of water, young growth 7.4 inches, grass-herbs 6.1 inches, and bare ground 4.1 inches. These losses were from gravelly soils 48 inches deep. Areas cleared of brush by bulldozing lost half as much water as untreated brush areas.

IT TAKES HEAT TO MELT SNOW

- How does heat penetrate the snow pack?
    - Under different forest stands and slope conditions, how does radiation from the sun and re-radiation from the trees vary?
- How does wind affect heating of the snow pack?
    - How can the forest be managed to retard snow melt?

FIRST RESULTS INDICATE . . . .

. . . . that forests should be cut to shade the snow and minimize re-radiation from the trees—make successive strip cuttings progressively toward the south to create a "wall and step" forest with the wall at the south.



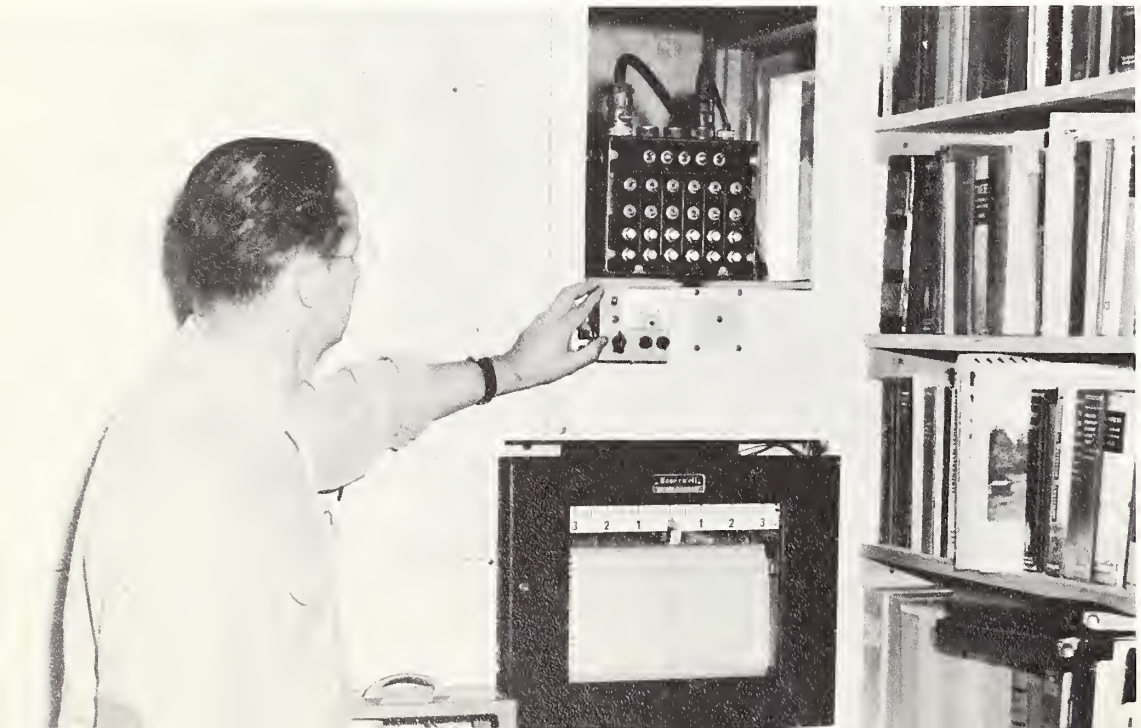
Learning . . . . . .

HOW LOGGING AND BRUSH REMOVAL AFFECT WATER YIELD

Several short-term studies of the effects of logging and brush removal on water yield and sedimentation have been started.

How does strip cutting or block cutting affect snow accumulation and melt?

What effect does brush clearing and planting have upon water losses, streamflow, sedimentation, and fish habitat?



SPEEDING BASIC RESEARCH RESULTS

A vital part of research is the job of collecting and analyzing large volumes of data.

Modern equipment is helping. A newly developed micro-meteorological data logger measures temperatures, radiation, humidity, and wind direction and velocity in the forest . . . transmits this information directly from forest to recorder . . . and produces a machine-punched tape ready for the electronic computer.

From the computer, sometimes in minutes, come research answers that once took months of tedious, manual computation.

In summary:

THESE SNOW STUDIES ARE AIMED AT DEVELOPING AND TESTING WAYS OF IMPROVING CALIFORNIA'S WATER SUPPLY THROUGH FOREST AND LAND MANAGEMENT IN THE SNOW-ZONE

Some of the principal questions and preliminary answers are given in this pamphlet and in the following publications:

1. "Forest cover effects on snow accumulation and melt, Central Sierra Snow Laboratory" by H. W. Anderson. Trans. Amer. Geophys. Union 37(3):307-12, 1956, 38 (1):116, 1957.
2. "Anti-freezing hoods for V-notch weirs" by Carl O. Johannessen. Jour. Forest. 55(8):590, 1957.
3. "Operation Wet-Blanket gets underway" by H. W. Anderson, Abstracted in Trans. Amer. Geophys. 38(3):414, 1957.
4. "Relating sediment yield to watershed variables" by H. W. Anderson. Trans. Amer. Geophys. Union 38(6):921-924, 1957.
5. "Soil vegetation survey of a Central Sierra Snow Zone watershed" by R. E. Nelson. CF&RES Misc. Paper 21, 43 pp. illus. Dec. 1957.
6. "Snow on forested slopes" by H. W. Anderson and T. H. Pagenhart. 25th Ann. Western Snow Conf. Proc. pp. 19-23, 1957.
7. "Wind direction during snowfall at Central Sierra Snow Laboratory" by Arnold Court. 25th Ann. Western Snow Conf. Proc. pp. 39-43, 1957.
8. "New meteorological and snow studies in the central Sierra" by K. J. Walsh, 25th Ann. Western Snow Conf. Proc. pp. 43-45, 1957.
9. "Snow survey from the snow surveyor's side" by P. J. Wyckoff, 25th Ann. Western Snow Conf. pp. 57-59, 1957.
10. "Watershed management—an annotated bibliography of erosion, streamflow, and water yield publications by the California Forest and Range Experiment Station" by Clark H. Gleason, CF&RES Tech. Paper 23, 79 pp., illus. Jan. 1958.
11. "Progress Report, 1957-58, Cooperative snow management research" by H. W. Anderson, PSWF&RES, 56 pp. illus., proc., June 30, 1958.
12. "Water yield control through management in snow pack watersheds" by Henry W. Anderson, Proc. First Intersociety Conf. on Irrig. and Drainage, pp. 13-18, March 1959.
13. "Snow management research in High Sierra Range" by R. M. Rice. Jour. of Range Mgmt. 12:13-16, 1959.
14. "Forest shade related to snow accumulation" by H. W. Anderson, R. M. Rice, and A. J. West. 26 Ann. Proc. Western Snow Conf. pp. 21-31, 1958.
15. "Selection of best snow course points" by Arnold Court. 26th Ann. Proc. Western Snow Conf. 1-12, 1958.
16. "Progress in snow management research in California" by H. W. Anderson. 26th Ann. Proc. Western Snow Conf. p. 12-21, 1958.
17. "Rain-snow flood sources, meteorologically defined" by H. W. Anderson. Presented at Amer. Meteorol. Soc. Session of AAAS at Logan, Utah, June 16, 1958. (Abstract) Bul. Amer. Meteorol. Soc. 39(3):174-5, 1958.
18. "Summer evapotranspiration measurements using a radioactive soil moisture probe" by K. R. Knoerr. Presented at SW Pac. Meeting Amer. Geophys. Union, 1959. (Abstract) Jour. Geophys. Res. 64(6): 691, 1959.
19. "Water losses in the Sierra Nevada" by A. J. West and K. R. Knoerr. Jour. Amer. Water Works Assoc. 51(4):481-88, 1959.
20. "Snow in forest openings and forest stands" by H. W. Anderson, R. M. Rice and A. J. West. Proc. Soc. American Foresters, pp. 46-50, 1958.

PACIFIC SOUTHWEST FOREST AND RANGE EXPERIMENT STATION
BERKELEY, CALIFORNIA

FOREST SERVICE U.S. DEPARTMENT OF AGRICULTURE

KEITH ARNOLD, *Director*

in cooperation with

CALIFORNIA DEPARTMENT OF WATER RESOURCES
SACRAMENTO, CALIFORNIA

DEPARTMENT OF WATER RESOURCES · STATE OF CALIFORNIA ·

HARVEY O. BANKS, *Director*

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During the next 25 years, several billions of dollars will be spent by state, federal and local agencies in the construction of water storage and distribution facilities to meet California's growing needs. The water resources to be captured and put to work by these physical facilities will come largely from 42 million acres of foothill and mountain watershed lands. Although the snow zone comprises only 12 percent of the watershed, the stream flow from this area makes up 50 percent of the State's total available water supply. Watershed management practices in this zone can have a significant effect on the quantity, quality and timing of this essential water supply. The solution to California's water problems involves, among other things, the development of new, better, and more complete answers in watershed management. These answers cannot be plucked from the air—they must result from painstaking surveys, studies, research, and coordinated land management effort of federal, state, and local governmental agencies, private organizations and individuals.

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